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Electromagnetic Rams

The present invention relates to electromagnetic rams.

Such rams are known and have various constructions but principally they are all variations of piston and cylinder devices with the output being coaxial with the centre line of the ram. This causes difficulty when used in a confined space as it means that for a full stroke, one requires twice the length of the stroke to,be available or for a part of the ram to be received in a recess in the mounting. This difficulty has resulted in electro magnetic rams being limited in their uses.

The present invention provides an electromagnetic ram where a member extending transverse to the axial direction is used to transfer movement of the armature to the outside of the ram through an axially extending slot.

In one embodiment, the ram is in the form of a stator provided with coils which cooperate with the magnetic field produced by a magnetic assembly on the armature to produce motion when energised. This in turn requires the coils to be wound in such a manner as to form a gap through which the transverse member may move.

Preferably, each coil is wound as a pair of coil sections in an approximation to a "figure of 8" and the coils are connected in sets of three so as to be capable of being energised by signals which are out of phase with each other, for example by 120°, to form a three phase drive.

In another embodiment, the ram is in the form of a stator provided with a permanent magnet in order to create a fixed field of alternate magnetic poles, and an armature having one or more coils wound on a former.

In this embodiment, the coils are conventional coils but it does require the provision of a special connector to provide power to the coils eg in the form of a flexible bend.

Advantageously, the permanent magnets of the stator are provided with pole pieces in the form of slotted discs and the pole pieces are preferably shaped in order to provide a desired shaping of the magnetic field.

In order that the present invention be more readily understood, an embodiment thereof will now be described with reference to the accompanying drawings, in which,

Fig 1 is a sectional side view of a first embodiment of an electromagnetic ram according to the present invention;

Fig 2 is an end view of the ram shown in Fig 1;

Fig 3 is a diagrammatic representation of a coil formed by a pair of coil sections; and

Fig 4 is a diagrammatic side view of another embodiment of the present invention.

Referring to Fig. 1, an electromagnetic ram comprises a cylindrical stator 11 formed from a steel outer tube within which is mounted an armature 12 for movement along the ,length of the stator 11.

The armature 12 is shorter than the stator 11 and is provided with a transversely directed member 14 which can take any convenient form but in this case is shown as a fin 14 which is elongate in the axial direction. The fin 14 is received in an axially extending slot 15 provided in the wall of the stator 11.

The armature 12 is constructed from one or more assemblies of a permanent magnet member 17 which is axially magnetised and sandwiched between two pole pieces 18. If necessary, the pole pieces may be tapered towards their radial edges so as to reduce the field in the core and also the mass of the armature. It is also possible to insert a thin compliant disc between the pole pieces of adjacent magnetic assemblies. This will allow for manufacturing tolerances but also permits rams with long stators being formed which utilise an armature having a number of magnetic assemblies.

Within the steel outer tube, the stator is provided with especially wound coils which leave a gap through which the member 14 may extend. As shown in Fig. 3, one way of achieving this is to wind each coil in the form of two coil portions in the form of a "Figure of 8". The coils are assembled in sets of three

(one pair of coil sections for each of three phases for each magnetic period). The current for each phase must alternate in direction hence the way in which the coils are wound without crossing the gap of the axially extending slot 15 in the stator. The magnetic assembly or assemblies project a strong magnetic field radially outwards through the coils of the stator; the magnetic flux returning via the outer steel tube that completes the assembly.

The interior of the stator 11 is preferably lined with a hard, slotted dielectric tube that serves as a bearing and seal surface. The armature 12 is provided with a bearing surface or surfaces e.g. in the form of piston rings which are arranged to slide along the hard dielectric tube.

Each assembly of a permanent magnet member 17 sandwiched between pole pieces 18 is preferably circular in axial cross-section. Because the armature 12 may be constructed from a number of assemblies it is possible to allow relative pivotal movement between each assembly or between groups of assemblies in any direction about the central axis. Thus, the armature, being carried on a series of bearing rings running on the stator lining tube which is made of a hard dielectric material, is able to follow irregularities, or even deliberate curvature , of the axis of the cylinder. This is a significant advantage if the ram is required to curve upwards or around an obstacle. It also provides tolerance to structural misalignments resulting from mechanical stress, temperature gradients or damage. While compliant discs between assemblies might be sufficient to provide the necessary amount of relative movement, other mor complex coupling arrangements may be used depending upon the application. Further, the fin 14 may need to be articulated or the connection between the armature 12 and the fin 14 may need to be articulated.

With this basic electromagnetic construction, it is possible to forth a number of different actuators. For example, if the stator is a closed cylinder eg sealed ends are provided to the tube shown in Fig 1, and the actuator is fitted with a circumferential seal and thus forms a piston, a rodless pneumatic actuator can be

formed when the interior is filled with a gas e.g. air which can be supplied from a fixed or variable pressure source. This in turn requires a sliding pressure seal 16 to be provided in the slot 15. Otherwise, the slot 15 need only have a protective seal against dirt and other contamination.

Also, the shape of the cylinder need not be constrained to be a circular cross section but may be elliptical so as to ensure that the fin 14 runs truly down the centre of the slot and can tolerate side forces.

Further, the slotted stator may itself be curved and if curved to a uniform radius would allow the fin of the armature to move in an arc of a circle. In this construction it may be essential to use compliant discs between each magnetic assembly in view of the fact that the armature slides against the lining tube provided on the stator. Consequently, if the fin 14 is replaced by or coupled to a. radius arm, the arm could be connected to an orthogonal shaft so that the forces exerted on the armature exert a torque on that shaft. It will be understood that by this means a high-torque may be directly produced with the minimum of moving parts. Further, if the arc is continued to a complete circle around the shaft in question, this allows the armature to be lengthened so as to fill the whole stator thus producing the maximum possible torque. The armature may then be caused to rotate continuously if required. This in turn forms a toroidal rotary motor which could be used in the precise angular positioning of optical or other special equipment.

Additionally, more than one ram can be utilised to effect movement of a single member. In other words, two or three rams could be mounted on either side of and connected to a common actuator member which in turn may have an extension projecting out of a housing. The overall length of the system need be no longer than the length of one ram but the output will of course be a multiple of that of a single ram.

The above embodiment is described as a ram having a permanent magnet armature and operating as a three phase synchronous machine. Other

constructions are possible such are one wh a the armature uses coils and the stator is formed with permanent magnets. Fig 4 shows diagrammatically one form of ram having such a construction. Here, the armature 12 is formed by a number of conventional coils 20 wound on a steel core 21, the coils being supplied with power by means of a trailing lead 22 of sufficient length to permit the armature to travel along the stator.

The stator 11 is formed by a number of permanent magnet section 24 poled to form alternating magnetic poles along the length of the stator 11. Each permanent magnet section 24 comprises a permanent magnet 24a and pole pieces 24b. It is preferred to shape the pole pieces 24b so that they appropriately shape the magnetic field. In this case, they taper uniformly towards the periphery of the permanent magnet of each section. This has the effect of decreasing the strong magnetic field around the outside of each section 24.

The sections 24 are each slotted and the slots are aligned so as to permit a transversely entering fin (not shown) attached to the armature 12 to be freely moved with the armature as in the first embodiment.

It is also possible to construct coils in order to form either the stator or armature as desired. In this technique when applied to a stator, the stator can be formed from a stock of planar iron rings separated from each other by cylindrical iron rings in order to form slots in a generally continuous iron cylinder. Each coil of copper is separately fitted into the slot between planar iron rings and appropriately energised to provide axially alternating magnetic poles. The iron structure could be replaced by a cast and/or metal component. Additionally, the stator may be designed to induce eddy currents in a passive armature so as to produce a low-cost machine suitable for opening doors or moving curtains.

One particular use of the ram as described is in an elevator where two or four slotted rams may be arranged against the inside walls of the elevator shaft, driving and guiding the cage silently, directly and precisely.

It will be appreciated that many uses of the actuator will require the

presence of a position detector in order to provide a feedback signal to a control unit in order to properly control the relative motion of the actuator by appropriate switching of the stator coils. This is not shown in the drawings but its location will depend to a large extent on the use to which the actuator is put and the actual construction of the actuator.

In the case of an elevator, the deadload of the cage and its payload is supported by gas within the stator. The exact value of this pressure is automatically adjusted by a small valve system and a small standby compressor. The gas pressure is controlled by a simple algorithm that integrates the value of the current supplied to the actuator in order to compensate for temperature changes, lenses, load changes and elevator parking arrangements. Since air is not consumed during elevator motion the compressor need not be of a large capacity.

With long stators such as are envisaged with elevators, the stator coils should be divided into relatively short sections. This permits only those sections of the stator coil assembly adjacent the armature to be energised and switched thus improving power efficiency.